New Rice Could Benefit Malnourished Populations

SCOTT BAUER (K9950-1)

Geneticist J. Neil Rutger compares golden-hulled low-phytate rice (left) with rice that lacks the color-coding gene.

In ancient Asian civilizations, rice was believed to be a gift from the gods. Its influence on various cultures is still evident. Rice is revered today for its nutritional value and plays an important role in the diets and economies of nations around the world.

And now, rice grains that contain less phytic acid could mean better nutrition for the world's malnourished peoples, more nutritious animal feed, and less potential for water pollution from manure.

Humans need minerals to stay healthy, and people rarely have phosphorus deficiencies. But cereals like rice store most phosphorus in the grain as phytic acid, which can't be digested by one-stomached animals like fish, chickens, pigs, and humans. It binds to minerals such as iron, calcium, magnesium, and zinc in the slightly acidic conditions in our intestines. Because phytic acid is poorly digested and used, the minerals it binds to are less available to our bodies.

While phytic acid is involved in many necessary roles in seeds, people in nations with mainly grain-based diets could use less of this compound in their food. Livestock too could still be healthy with less of it in their feed. And the environment would benefit if less undigested phosphorus were excreted in manure, because it can lead to pollution of lakes and streams.

Scientists at the Dale Bumpers National Rice Center in Stuttgart, Arkansas, wanted to reduce the amount of phytic acid in rice. J. Neil Rutger, director and supervisory geneticist at the center, produced new breeding stock—or germplasm—for creating improved varieties. He enlisted the expert assistance of geneticist Victor Raboy, who developed the patented technique that yields grains with lower amounts of phytic acid. Raboy, based at the ARS' Small Grains and Potato Germplasm Research Unit in Aberdeen, Idaho, used the technology to develop new types of corn, barley, and soybeans. This is the first time his technique has been used to produce low-phytic-acid rice. The resulting rice contains only half the phytic acid of its parent, which translates to enhanced nutritional value.

For more than 30 years, Rutger has worked with rice breeding lines to enhance desirable qualities and diminish weaknesses. To create a new, low-phytic-acid plant, Rutger selected Kaybonnet—one of the most popular types of rice grown in Arkansas—when the project began in 1994. Germplasm he developed was sent to Raboy's laboratory, where it was screened for low-phytic-acid mutations. The first such mutation was

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Bottom: Parent variety of rice with normal phytic acid. Middle: The new low-phytic-acid variety. Top: The new variety given a gene for golden hull color to help identify it.

dubbed KBNT *lpa*1-1 (short for Kaybonnet low-phytic-acid gene 1). Initial analyses showed that phytic acid was reduced by 45 percent in this rice. Later, Steven R. Larson, then a postdoctoral scientist with Raboy and now with ARS' Forage and Range Research Laboratory in Logan, Utah, carried out the genetic mapping of KBNT

*lpa*1-1 using populations Rutger constructed for this purpose.

To further study the phytic acid content of this new breeding line, chemist Rolfe J. Bryant at Stuttgart and Rutger compared it to common cultivars and to its parent. First, different lines were milled. Milling, often called whitening, removes the outer bran layer of the rice grain, leaving a core that is mostly carbohydrates. Milling makes brown rice become white rice. Vital nutrients are found in the bran, including about two-thirds of the phytic acid.

Rutger worked with Bryant to analyze the new line and other varieties. Bryant compared samples from different degrees of milling and examined their phytic acid content. He found that the total phytic acid concentration in the brown rice of KBNT *lpa*1-1 (before the bran is removed) was 49 percent lower than that of its parent—a characteristic improved through breeding. KBNT *lpa*1-1's phytic acid content before milling was also 25 to 52 percent less than other varieties they tested, with an average of 42 percent less. Although a small amount of phytic acid appears to remain in the white rice even after intensive milling, the phytic acid content of KBNT *lpa*1-1 was still less than or equal to that of its parent.

Although there is less phytic acid in the new line, it has more phosphorus available for digestion and absorption by the body. One trade-off was a 10-percent lower grain yield than its parent. But decreased yield is common initially with many crop breeds and could be bred out eventually, Rutger says.

"If used in animal feeds, the bran portion of KBNT *lpa*1-1 rice should be of greater nutritional value than brans from other rice varieties," Rutger points out. "This means less undigested phosphorus in the animal's manure."

ARS and the University of Arkansas released the new rice to breeders and researchers earlier this year. Rutger and Raboy are continuing to screen for other genes with the low-phytic-acid traits.

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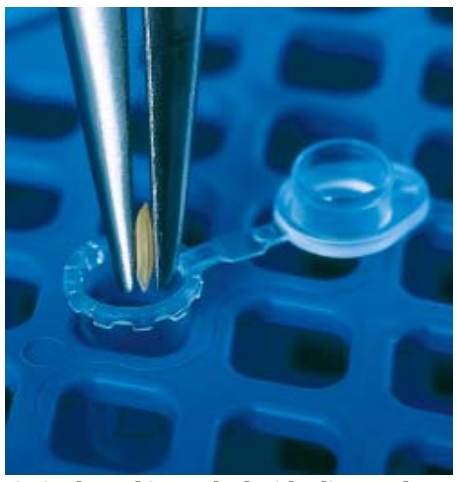

A rice kernel is crushed with pliers and inserted into a microcentrifuge tube for phytic acid extraction and analysis.

The next phase of their research was to make low-phytic-acid rice visually distinguishable from other varieties now in the marketplace. To do that, the scientists borrowed a color-imparting gene from a golden-hulled rice no longer marketed and introduced it into KBNT *lpa*1-1. Then they selected resulting lines that had both low-phytic-acid characteristics and a gold hull. The golden color of new rice will differentiate it from other varieties and prevent mixups.

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Chemist Rolfe Bryant mixes a rice extract with a reagent that will reveal the amount of phytic acid in the kernel.

Rutger hopes studies will be held where volunteers will eat meals prepared with the new rice to see whether their mineral absorption increases. That's what happened to volunteers who participated in a study of low-phytic-acid corn that Raboy developed. (See "Feeling Weak? Try the Tortillas!" *Agricultural Research,* March 2000, p. 13.)

"Volunteers who ate tortillas made with low-phytic-acid corn flour absorbed 50 percent more iron than those who ate tortillas prepared with conventional corn flour. We expect similar results with volunteers who eat KBNT *lpa*1-1 rice," Raboy says.

"This rice line would be of significant nutritional value to developing nations where mineral deficiency is common," Rutger says. "There has been a great deal of interest in our research from organizations in various nations."—By **Jim Core,** ARS.

This research is part of Plant, Microbial, and Insect Genetic Resources, Genomics, and Genetic Improvement, an ARS National Program (#301) described on the World Wide Web at http://www.nps.ars.usda.gov.

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